

1619

BYTHOTREPHES CEDERSTROEMI
(SCHOEDLER) IN MUSKOKA LAKES:
FIRST RECORDS OF THE
EUROPEAN INVADER IN
INLAND LAKES IN CANADA

MARCH 1992



Environment
Environnement

ISBN 0-7729-9462-5

BYTHOTREPHES CEDERSTROEMI (SCHOEDLER) IN MUSKOKA LAKES:
FIRST RECORDS OF THE EUROPEAN INVADER
IN INLAND LAKES IN CANADA

Report Prepared For:

Limnology Section
Water Resources Branch
Ontario Ministry of the Environment

MARCH 1992



Cette publication technique
n'est disponible qu'en anglais.

Copyright: Queen's Printer for Ontario, 1992
This publication may be reproduced for non-commercial purposes
with appropriate attribution.

PIBS 1674
log 91-2345-072

BYTHOTREPES CEDERSTROEMI (SCHOEDLER) IN MUSKOKA LAKES:

FIRST RECORDS OF THE EUROPEAN INVADER

IN INLAND LAKES IN CANADA

Report prepared by:

Norman D. Yan

Ontario Ministry of the Environment, Water Resources Branch, Dorset Research Centre,
P.O. Box 39, Dorset, Ont. POA 1E0, Canada

Warren I. Dunlop

Ontario Ministry of Natural Resources, Muskoka Lakes Fisheries Assessment Unit, P.O. Box
1138, Bracebridge, Ont., P1L 1V3, Canada

Trevor W. Pawson

Ontario Ministry of the Environment, Water Resources Branch, Dorset Research Centre,
P.O. Box 39, Dorset, Ont. POA 1E0, Canada

and Lori E. MacKay

Ontario Ministry of Natural Resources, Muskoka Lakes Fisheries Assessment Unit, P.O. Box
1138, Bracebridge, Ont., P1L 1V3, Canada

ABSTRACT

The presence of the European invader *Bythotrephes cederstroemi* is documented in the plankton of eight large, recreational lakes in south-central Ontario, Canada - Lake Muskoka, Lake Joseph, Lake Rosseau, Fairy Lake, Mary Lake, Peninsula Lake, Lake Vernon and Go Home Lake. These observations represent the first evidence that *B. cederstroemi* has invaded inland lakes in Canada.

INTRODUCTION

Bythotrephes cederstroemi Schoedler (Cercopagidae, Onychopoda) is a large, predaceous, Palearctic zooplankter that invaded each of the Laurentian Great Lakes during the 1980's (Bur et al. 1986; Lange and Cap 1986; Lehman 1987; Evans 1988; Cullis and Johnson 1988). In Europe, *Bythotrephes* inhabits lakes that range widely in size, depth, hardness, acidity, colour, nutrient status, and fish assemblages (Nilsson and Pejler 1973; Hobæk and Raddum 1980; Næsje et al. 1987). Therefore, it is safe to assume that the majority of inland lakes in temperate North America offer suitable habitat to the invader. There was no evidence that *B. cederstroemi* has colonized any inland lake in Canada, despite the availability of habitat. It is our purpose to report the presence of *B. cederstroemi* in eight of the twelve largest lakes in the Moon River/Go Home River watershed in the District of Muskoka in south-central Ontario, Canada.

STUDY LAKES

The twelve study lakes (Table 1, Figure 1) are located in the Moon River/Go Home River Watershed, tertiary watershed number 2EB of Cox (1978). The lakes are all large (Table 1). They have soft waters (range in conductivity of 30-69 μS at 20°C), and are circum-neutral in reaction, suffering little from the impacts of acid precipitation (pH of 6.7-7.4, Gran alkalinity of 60-220 $\mu\text{eq/L}$). They are oligotrophic, with total phosphorus levels generally $<10 \text{ mg/m}^3$, and nitrogen/phosphorus ratios >30 by weight. Reid and Girard (1988) and Yan et al. (1991) provide additional information on the morphometry, water chemistry, and physical limnology of the lakes.

With the exception of Three Mile and Go Home lakes, the study lakes support fish communities dominated by lake trout (*Salvelinus namaycush*), smallmouth bass (*Micropterus dolomieu*) and coregonids. The fish communities of Three Mile and Go Home lakes are typical of more mesotrophic lakes, containing walleye (*Stizostedion vitreum vitreum*) and

smallmouth bass. All twelve lakes also support yellow perch (*Perca flavescens*), as well as varying numbers of other percids, centrarchids and cyprinids (Ontario Ministry of Natural Resources, unpublished data).

The lakes are a very valuable resource in central Ontario. They are used for recreation by thousands of cottagers each summer (Table 1). They supply the drinking water for and receive domestic waste water from three towns with about 10,000 permanent residents (Huntsville, Bracebridge and Gravenhurst), and from several smaller villages. They support important summer and winter recreational fisheries for lake trout, smallmouth bass and walleye. Estimates of fishing effort on lakes Joseph and Rosseau range from 20,000 - 40,000 angler-hours/y, for example (Ontario Ministry of Natural Resources, unpublished data).

METHODS

Two sampling methods were employed routinely, one on Lakes Joseph, Muskoka, and Rosseau, and a second on the remaining lakes. Zooplankton were collected from several widely-spaced stations in Lake Joseph, Lake Muskoka, and Lake Rosseau on a monthly schedule over the ice-free seasons of 1989 and 1990 (Table 1). At each station, triplicate vertical hauls from 0.5 m above the sediments to the lake surface were taken with either an 11.5 cm or a 13 cm diameter, non-metered conical tow net constructed of 76 μm mesh. The net was hauled at 0.4 m/sec. The contents of the three hauls were pooled prior to enumeration. Volumes of samples were calculated assuming 100% filtration efficiency, a reasonable assumption given the 13:1, filtering area:mouth area ratio of the net.

Zooplankton were collected from the remaining lakes in vertical hauls with a metered, 46 cm diameter, conical tow net constructed of 150 μm mesh. Hauls were taken through 30 m at stations deeper than 30 m, and from 2 m above the bottom at shallower stations. Occasionally, zooplankton were also collected in horizontal hauls using either the 46 cm diameter net, or a 47.5 cm diameter, metered, closing tow net constructed of 500 μm mesh. Samples were collected at several widely-spaced stations in each lake (Table 1) in July or

August of 1990 and/or in June of 1991. Measured filtration efficiencies, used to calculate volumes of lake water sampled, averaged 59.8%. Yan et al. (1991) provide maps showing all sampling locations.

In addition, we examined zooplankton samples collected by B. Hutchinson (Ontario Ministry of the Environment) as metered vertical net hauls from 14 stations in Lake Rosseau on July 27, 1983, 15 stations from Lake Muskoka on July 31, 1984, and from 12 stations in Lake Joseph on August 8, 1984. To our knowledge, no historical samples from the other study lakes exist.

All samples were preserved in the field with a 4 or 5% sucrose formalin solution. They were subsequently examined in their entirety for *B. cederstroemi*.

RESULTS

B. cederstroemi was not detected in any of the samples collected from Lakes Muskoka, Rosseau and Joseph in 1983 and 1984, nor was it reported by Michalski et al. (1973) in their 1969 collections. In 1989 and 1990, *B. cederstroemi* was present in all three of these lakes. In the 1989 collections from Lake Muskoka, it was recorded in almost one-third of the 45 collections, and in four of the five months of sampling. In the 1990 collections from Lake Rosseau, it was recorded in all of the monthly sampling runs (Table 1).

B. cederstroemi was recorded in the 1990 collections from Fairy and Mary Lakes, but not in the six remaining lakes sampled in that year. Its absence from Lake Vernon and Peninsula Lake was a bit surprising because these lakes are connected with Fairy Lake by broad, flat channels. In the spring of 1991, *B. cederstroemi* was collected in horizontal hauls at the lake surface in both Lake Vernon and in Peninsula Lake. Two individuals were also collected at the last of five stations visited in Go Home Lake, downstream of Lake Muskoka (Table 1).

In summary, the presence of *B. cederstroemi* is confirmed in eight of twelve large lakes sampled in the Moon River/Go Home River watershed - Go Home Lake, Lake Muskoka, Lake Rosseau, Lake Joseph, Mary Lake, Fairy Lake, Peninsula Lake and Lake Vernon. *B. cederstroemi* were not collected in Skeleton Lake, Three Mile Lake, Lake of Bays or Kawagama Lake. Either the invader was not present in these lakes, or it was present at densities below our limits of detection. These limits can be approximated from the summed sample volumes to be 0.2, 0.67, 0.053, or 0.08 animals m⁻³, respectively, for these lakes.

DISCUSSION

B. cederstroemi has been observed in only one other set of inland lakes in North America. Jeff Schuldt and Glen Merrick (University of Minnesota at Duluth, personal communication) collected *B. cederstroemi* in plankton hauls in Fish Lake, Boulder Lake, and Island Lake, three lakes in the Cloquette River watershed in northern Minnesota, U.S.A., in September, 1990. They suspected that *B. cederstroemi* had been introduced into these lakes by anglers.

Anglers may have also introduced *B. cederstroemi* into the Muskoka Lakes. They are suspected, for example, of introducing northern pike (*Esox lucius*), margined madtom (*Noturus insignis*), and black crappie (*Pomoxis nigromaculatus*) into various lakes in the watershed, either deliberately, or accidentally through bait-bucket introductions. Operators of marinas on Lake of Bays, Lake Muskoka, Lake Rosseau, Lake Joseph, and Fairy Lake confirmed that boats are occasionally moved from the Great Lakes into their lakes. They also indicated that boats are frequently moved among the Muskoka lakes. This should speed the dispersal of *B. cederstroemi* within the watershed, now that it is established. There are 2022 lakes >1 ha in this watershed (Cox 1978).

Of course we can not be certain how *B. cederstroemi* invaded the Muskoka lakes. The lakes are all isolated from Georgian Bay by several waterfalls and rapids; hence, colonizers could

not have entered the lakes directly. In addition to boaters, anglers, or seaplanes, waterfowl may have served as the vector of colonization. It would be a short flight for migrating waterfowl from Georgian Bay to any of the colonized lakes (Figure 1).

At the moment we do not know how, or even if, the pelagic food webs of the Muskoka lakes will respond to the presence of *B. cederstroemi*. The European literature provides little guidance, because the consumption rates of *B. cederstroemi* have not been compared with the production rates of its prey in any European lake. The impacts of the invader on the plankton assemblages of the Laurentian Great Lakes are also a source of controversy. Lehman (1988) and Scavia et al. (1988) suggested that *B. cederstroemi* has reduced the densities of *Daphnia* in Lake Michigan. However, Sprules et al. (1990) reported no evidence of such a decline in their Lake Michigan data. Because investigations such as these are in their early stages, and because Great Lakes food webs may not yet have stabilized in response to the invader, the full impacts of *B. cederstroemi* on the Great Lakes may not be understood for some time.

The impacts of *B. cederstroemi* on Shield lakes will not be understood without research. Obvious initiatives which would improve our understanding include studies of 1) the abundance, spatial distribution, migratory behaviour, production and life history of *B. cederstroemi* populations in several Shield lakes with differing fish assemblages, 2) the interaction of *B. cederstroemi* with other large, planktonic macro-invertebrate predators in Shield lakes, including mysids, mites, larval Chaoborus, and *Leptodora*, 3) prey preferences of *B. cederstroemi* in Shield lakes, 4) predation rates of *B. cederstroemi* and production rates of their preferred prey, and 5) the spread of *B. cederstroemi* across the Shield. Little or no historical zooplankton data exist for the vast majority of Shield lakes that will ultimately be colonized by *B. cederstroemi*. Therefore, paleolimnological assessments of changes in zooplankton assemblages may also be a fruitful avenue of research for such lakes (e.g., Kitchell and Kitchell 1980).

ACKNOWLEDGEMENTS

We thank Claudiu Tudorancea for examining the current and historical samples from Lakes Muskoka, Rosseau and Joseph, Jeff Schuldt for allowing us to report the presence of *B. cederstroemi* in northern Minnesota, Barbara Hutchinson for providing historical zooplankton samples from three of the study lakes, and the Planning Office of the District Municipality of Muskoka for providing us with the number of cottage properties on the study lakes.

REFERENCES

- Bur, M.T., D.M. Klarer and K.A. Krieger. 1986. First records of a European cladoceran, *Bythotrephes cederstroemi*, in lakes Erie and Huron. J. Great Lakes Res. 12: 144-146.
- Cox, E.T. 1978. Counts and measurements of Ontario Lakes by Watershed Unit (Fisheries Branch), Ontario Ministry of Natural Resources, Toronto, Ontario. 114 p.
- Cullis, K.I. and G.E. Johnson. 1988. First evidence of the Cladoceran *Bythotrephes cederstroemi* Schoedler in Lake Superior. J. Great Lakes Res. 14: 524-525.
- Evans, M.S. 1988. *Bythotrephes cederstroemi*: its new appearance in Lake Michigan. J. Great Lakes Res. 14: 234-240.
- Hobæk, A. and G.G. Raddum. 1980. Zooplankton communities in acidified lakes in southern Norway. SNSF project report IR 75/80. SNSF project, Box 61, 1432 Aas-NLH, Norway. 132 p.
- Kitchell, J.A. and J.F. Kitchell. 1980. Size-selective predation, light transmission, and oxygen stratification: Evidence from the recent sediments of manipulated lakes. Limnol. Oceanogr. 25: 389-401.
- Lange, C. and R. Cap. 1986. *Bythotrephes cederstroemi* (Schodler), (Cercopagidae: Cladocera): a new record for Lake Ontario. J. Great Lakes Res. 12: 142-143.
- Lehman, J.T. 1987. Palearctic predator invades North American Great lakes Oecologia (Berl). 74: 478-480.

- Lehman, J.T. 1988. Algae biomass unaltered by food-web changes in Lake Michigan. *Nature*. 332: 537-538.
- Michalski, M.F.P, M.G. Johnson and D.M. Veal. 1973. Muskoka Lakes water quality evaluation, Report Number 3; eutrophication of the Muskoka Lakes. Ontario Ministry of the Environment Report, Water Res. Branch, Toronto, Ontario. 84 p.
- Næsje, T.F., B. Jonsson, L. Klyve and O.T. Sandlund. 1987. Food and growth of age-0 smelts, *Osmerus eperlanus*, in a Norwegian fjord lake. *J. Fish. Biol.* 30: 119-126.
- Nilsson, N.A. and B. Pejler. 1973. On the relation between fish fauna and zooplankton composition in North Swedish lakes. *Inst. Freshwater Res. Drottningholm. Rep. No.* 53: 52-77.
- Reid, R.A. and R. Girard. 1988. Muskoka Lakes Project Report, Ontario Ministry of the Environment Data Report DR 88/1, Water Resources Branch, Limnology Section. 58 p.
- Scavia, D., G.A. Land, and J.F. Kitchell. 1988. Dynamics of Lake Michigan plankton: a model evaluation of nutrient loading, competition, and predation. *Can. J. Fish. Aquat. Sci.* 45: 165-177.
- Sprules, W.G., H.P. Riessen and E.H. Jin. 1990. Dynamics of the *Bythotrephes* invasion of the St. Lawrence Great Lakes. *J. Great. Lakes Res.* 16: 346-351.
- Yan, N., W. Dunlop, T. Pawson and L. MacKay. 1991. *Bythotrephes cederstroemi* in south-central Ontario lakes: a review of the biology of the European invader, and first records of its occurrence in the zooplankton of inland lakes in Canada. Ontario Ministry of the Environment, Water Resources Branch, Limnology Section Report. 44 p.+ appendices.

Table 1: Summary of selected data on the location and morphology of the study lakes, on the sampling protocol for *B. cederstroemi*, and on the abundance of *B. cederstroemi* in the study lakes. The latitude (Lat), longitude (Long), lake area and elevation (Elev) are provided, followed by the year of sampling (Year), the number of stations visited in the year (NS), and the number of dates (ND) all stations were visited. The gear code (GC) and sampling protocol code (SC) are indicated. *B. cederstroemi* data summarized include the average detection limit (DL) for all stations and dates calculated assuming 1 *B. cederstroemi* was observed in each sample. The percent of samples in which *B. cederstroemi* was observed is listed (Occ), as is the total number of animals observed (Total Num) in the year. The range in abundances of samples with *B. cederstroemi* is given along with the number of the months in which it was observed (1-January, 2-February, etc.). Finally, the number of recreational properties on each lake is listed.

Lake	Lat	Long	Area (ha)	Elev (m)	Year	NS	ND	GC	SC	Bythotrephes data					Number of Cottages
										mean DL (#/m ²)	Occ (%)	Total Num	Range in abundance (#/m ²)	Month Num	
Fairy	4520	7911	711	284	1990	9	1	2	2	0.88	56	19	1.02-7.8	8	136
					1991	3	1	2	2	0.72	67	64	4.39-25.1	6	
Go Home	4501	7953	666	180	1991	5	1	2	2	0.56	20	2	3.05	6	433
					1989	7	7	1	1	1.89	6	2	0.85-2.86	6,7	792
Joseph	4511	7947	5156	225	1990	9	6	1	1	1.36	5	3	0.35-0.73	7,9	
					1990	7	1	2	2	0.89	0				900
Kawagama	4515	7904	6904	315	1990	12	1	2	2	0.72	0				1784
					1990	7	1	2	2	1.59	67	11	0.89-5.5	7	248
Mary	4515	7915	1065	281	1990	9	5	1	1	2.68	29	33	1.8-11.8	6,7,8,10	3986
					1989	11	5	1	1	1.74	14	8	0.48-1.9	5,7	
Muskoka	4500	7925	12200	225	1990	2	1	2	2	0.61	0				313
					1991	2	1	2	2	0.51	0				
Peninsula	4520	7906	865	284	1991	1	1	3	3		100	11	2.33	6	
					1989	7	5	1	1	3.26	14	8	1.17-6.5	7,9,10	907
Rosseau	4510	7935	6374	226	1990	10	6	1	1	2.05	18	11	0.29-17.5	6,7,8,9,10	
					1990	3	1	2	2	0.9	0				348
Skeleton	4515	7927	2154	281	1990	4	1	2	2	8.6	0				340
					1990	2	1	2	2	0.66	0				337
Three Mile	4510	7927	929	247	1990	1	1	2	2	0.35	0				
					1991	1	1	2	2		100	6	0.32	6	
Vernon	4520	7917	1505	284	1991	1	1	3	3						
					1991	1	1	3	3						

* Gear Codes - 1: 76 µm mesh, 11.5 or 13 cm diameter, un-metered, conical tow net
 2: 150 µm mesh, 46 cm diameter, metered, conical tow net
 3: 500 µm mesh, 47.5 cm diameter, metered, closing, conical tow net

Sampling Codes - 1: pooled triplicate vertical hauls from 0.5 m above bottom
 2: single vertical haul from 30 m, or from 2 m above bottom if the station was <30 m deep
 3: horizontal haul at the lake surface

Figure 1: Location of the study lakes in the Moon/Go Home Rivers watershed.



